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DEVICE AND METHOD FOR CONTROLLING A THICK MATTER PUMP

BACKGROUND OF THE INVENTION

Field of the invention

[0002] The invention concerns a device and a process for controlling a thick matter pump with two conveyor cylinders communicating via end openings in a material supply container operable in counter stroke by means of a hydraulic reversible pump and via these control hydraulic drive cylinders, with a hydraulic operated pipe switch provided within the material supply container, of which the inlet side is alternatingly connectible to one of the openings of the conveyor cylinders leaving open the respective other opening and on the outlet side connected with a conveyor conduit, wherein the passing-by of the piston is detected at each conveyor stroke in at least two sensor positions in predetermined spacing from each other and from the rod and/or bottom side end of the drive cylinder, and upon ending of the conveyor stroke, a switching or reversing process of the reversible pump and the pipe switch is initiated.

[0003] A device for control of a two cylinder thick matter pump of this type is known (DE 195 42 258), in which the end position of the piston of the drive cylinder can be determined by means of cylinder switch sensors or proximity sensors for producing end position signals. Here, the flow-through reversal of the reversible pumps is initiated by the end-position signal of the drive cylinder. As a rule, the end-position signal is conventionally triggered via the two cylinder switch sensors at the rod end of the cylinder. In the switching of the reversible pump and the pipe switch there always occur problems when the amounts to be conveyed are varied, for example, via a remote control. Therein it is to be taken into consideration, that the

switching of the reversible pump does not occur instantaneously. It requires rather a certain reversal time for the carrying out of the movement of the slant disk present in the reversible pump. The switching-over times, in the conventional reversible pumps, lie at approximately 0.1 second. In a two second stroke this reversal interval represents approximately 5% of the stroke length. Further compounding this is additional delay times, for example for the switching of relays, which could lie in the same order of magnitude. This means, that for the switching of the reversible pumps, depending upon piston speed, distances can be achieved which could lead either to a banging of the piston at the base or lead to an incomplete emptying of the cylinder. For this reason there have already been provided cylinder switch sensors for signal production of the piston passage in the area of the end positions spaced apart from the rod or base side end of the cylinder. If the piston passes also through this sensor position, then there still remains available a certain amount of piston travel distance for switching over. With known two cylinder thick matter pumps the position of the cylinder switch sensors was so selected that at maximal possible piston speed a switching of the reversible pump, which just leads to a contact of the piston with the base, is made possible. If the piston travels slower than this maximum, then on the basis of the constant switch time of the reversible pump and the reaction time of the relays, this leads thereto, that the piston during this time does not run all the way to the adjacent base. Thus a residual amount of concrete remains in the cylinder, which during a piston stroke is not extruded out of the cylinder. This can lead to a hardening of the concrete and to an obstruction. In the case of single circuit pumps the one and the same hydraulic pump also switches over the pipe switch. This must occur at precisely the time at which the piston

reaches the base side or the rod side end. Only then is the pump pressure sufficient for the switching over of the pipe switch. A particular problem of the single circuit pump is thus comprised therein, that the time point of the switching of the reversible pump, the stopping of the piston and the switching of the pipe switch must be coordinated precisely to each other. In two circuit pumps, in which the pipe switch is switched over via a pressure accumulator, the coordination problems may be somewhat reduced. Similarly however herein there is also need for a suitable coordination to ensure that the piston so completely traverses the cylinder in order to avoid undesired residual amounts of concrete in the cylinders.

SUMMARY OF THE INVENTION

[0004] Beginning therewith, it is the task of the present invention to develop a device and a process for controlling a thick matter pump of the above described type, whereby a complete emptying of the cylinder at each piston stroke is made possible, and nevertheless an undesired banging of the piston at the end of the drive cylinder is avoided.

[0005] For the solution of this task the combination of characteristics set forth in Claims 1 and 6 is proposed. Advantageous embodiments and further developments of the invention can be seen from the dependent claims.

[0006] The inventive solution is based upon the idea that, with at least two cylinder switch sensors provided on any position in the drive cylinder, which are provided spaced apart from each other and from the two ends, a detection of movement of the drive piston is made possible, which, with the assistance of a computer assisted switching device with suitable software,

enables a complete detection of the course of movement of the piston along the work cylinder and therewith the solution of the above indicated problems. In order to accomplish this, it is primarily proposed in accordance with the invention, that the computer assisted switching device includes a measurement and evaluation routine for measurement-technical and/or computer assisted detection of the time/movement course of the piston on its way between the two cylinder ends, as well as for computing a therefrom derived time point for initiation of the switching of the reversible pump and the pipe switch.

[0007] One preferred embodiment of the invention envisions that the measurement and evaluation routine includes an algorithm for detecting the time of the piston passage at the location of the cylinder switch sensor as well as for calculating a therefrom derived initiation or trigger time point for a switching of the reversible pump and the pipe switch at each piston stroke, with taking into consideration of a predetermined or computed interval time of the piston until the respective impact at the cylinder end. The interval time of the piston is essentially comprised of the reaction time of the switch relay and the switching-over time of the reversible pump.

[0008] With constant operating mode, without changing the conveyed amounts, there can be computed or assigned at each time interval, which is measured as reference value for the speed, a initiation point for the switching over of the reversible pump and the pipe switch. The detection of time can in this case occur for example via a switch impulse for the pipe switch. The distance between two switches of the pipe switch correspond then to the measured stroke duration. With taking into consideration the measured stroke duration then, during passage of the piston

through one of the two cylinder switch sensors, the initiation time point for the switching can be determined. This value is approximately constant for one and the same type of pump design. A special circumstance occurs when the conveyed amount within the pipe stroke is to be changed. In this case a new conveyance mount must be taken into consideration and a corresponding residual run-time must be calculated in order to determine the precise initiation point.

[0009] A preferred design of the invention accordingly provides that the measurement and evaluation routine includes an algorithm for calculating the speed of the piston on its path between the cylinder switch sensors and a therefrom derived initiation point for the switching process, with taking into consideration of a predetermined or computed brake or dwell time of the piston until the respective end-impacting in the cylinders.

[00010] A preferred embodiment of the invention envisions that the measurement and evaluation routine consults preset values for the conveyor amounts of the reversible pump input in a preferably remote control device and an algorithm for determining the piston speed plot and the therefrom derived next initiation point in time for the switching process according to the magnitude of the currently set target value. Therein it is of particular value, when the measurement and evaluation routine includes an algorithm for determining the interval time or the travel path of the piston according to the magnitude of the instantaneous measured or calculated piston speed and a therefrom derived initiation time point for the switch process.

[00011] In accordance with the inventive process, it is primarily decided that the time movement sequence of the piston is measured and/or computed while on its path between the two cylinder ends and therefrom the respective next initiation or actuation point in time for the switching process is derived. A preferred embodiment of the invention envisions that the passage or transition of the pistons at the location of the cylinder switch sensors is detected in time-relation to each other, and that therefrom the initiation point in time for the respective following switching of the reversible pump and the pipe switch is computed, taking into consideration a predetermined or computed brake time of the piston until the respective end banging of the cylinder. Therein the speed of the piston on its way between the selected cylinder switch sensors can be computed and therefrom the next point in time for the switching process can be derived.

[00012] A further preferred mode of the inventive process is comprised therein, that the movement of the piston over time is changed via remote control demand values for the conveyed mounts, and that from the, according to the value or magnitude of the demand value calculated movement sequence of the piston, with taking into consideration of a thereby modified brake time, the next initiation or actuation point for the switching process is derived. For this it can be useful, that brake time or the interval path of the piston is determined from the measured or the computed instantaneous piston speed with respective taking into consideration of the device-specific response and switch times for the reversible pump, and therefrom calculates the respective next initiation point in time.

Brief Description of the Drawings

[00013] In the following the invention will be described in greater detail on the basis of illustrative embodiments shown in greater detail in schematic manner in the figures. There is shown

Fig. 1 A section of a two cylinder thick matter pump in partial sectional perspective representation;

Fig. 2 A circuit diagram of a computer-controlled drive hydraulic for the two cylinder thick matter pump;

Fig. 3 A section from Fig. 2 with a few indications of value for the computation of a preferred initiation time point;

Fig. 4 A speed-/time-diagram of the piston movement along the drive cylinders;

Fig. 5 A flow diagram of the measurement and initiation routine.

Detailed Description of the Invention

[00014] The control arrangement shown in Fig. 2 and 3 is intended for the thick matter pump corresponding to Fig. 1. The thick matter pump includes two conveyor cylinders **50, 50'**, of which the end openings **52** communicate in a material supply container **54** and alternatingly can be connected during the pressure stroke with a conveyor conduit **58** via a pipe switch **56**. The conveyor cylinders **50, 50'** are operated in counter stroke via hydraulic drive cylinders **5, 5'** and a reversible hydraulic pump **6**. For this purpose the conveyor pistons **60, 60'** of the

conveyor cylinder **50**, **50'** are each connected with a piston **8**, **8'** of the drive cylinder **5**, **5'** via a common piston rod **9**, **9'**.

[00015] In the illustrative embodiment the drive cylinders **5**, **5'** are acted upon with hydraulic pressure on the base side via hydraulic lines **11**, **11'** of the hydraulic circulation assisted by the reversible pump **6** and are, on their rod side end, connected hydraulically with each other via an oscillating oil conduit **12**. The direction of movement of the drive pistons **8**, **8'** and therewith the common piston rods **9**, **9'** are reversed due to the flow-through direction of the reversible pump **6** being reversed via a reversing device **18** containing a computer **14** and a switch mechanism **16**. The reversible pump **6** has for this purpose a slant disk **62**, which for reversing is pivoted through its zero position, so that the conveyor device reverses the oil pressure in the hydraulic conduits **11**, **11'**. The conveyed amount of the reversible pump **6** can be varied, while keeping constant a predetermined rotational speed of a not shown drive motor, by changing the pivot angle of the slant disk **62**. The pivot angle of the slant disk **62** can therein be adjusted via a remote control device **64** with the support of a computer **14**.

[00016] The reversing of the reversible pump and the pipe switch **56** occurs as soon as the piston **8**, **8'** of the drive cylinders **5**, **5'** reach their end position. The reversing device evaluates output signals of the respective cylinder sensors **20**, **22** and **20'**, **22'**, provided respectively a distance from the rod side and base side ends of the two drive cylinders **5'**, **5'**, which on the output side are connected with the computer **14** of the control device **18**. The cylinder switch sensors react to the drive pistons **8**, **8'** running thereby during operation of the pump, and signal this occurrence to the computer input **66**, **68**.

Upon occurrence of the output signals a reverse signal **76** is initiated time-delayed in the reversing device, which reverses the reversible pump **6** via the adjusting mechanism **16**. In the sequence of the reversal process there is initiated in addition, via a signal **77**, a reversal of the pipe switch **56** via the direction control valve **79** and the plunger cylinder **72, 72'**. In normal operation it is primarily the signals of the rod side cylinder switch sensors **20, 20'** that are employed for producing a reverse signal. For this, the computer **14** includes a measurement and evaluation routine **40** (See Fig. 5), in which the initiation signal of the rod side cylinder switch sensors **20, 20'** are evaluated with formation of a reverse signal **76, 77** for the reversible pump **6** and/or the pipe switch **56**.

[00017] In the following there will be described in greater detail on the basis of Fig. 3 and 4 a method of calculating which forms the basis of the measurement and evaluation routine **40**.

[00018] In Fig. 3 the rod side cylinder switch sensors **20, 20'** are referenced with S_1 and S_2. In accordance therewith the sensor positions from the base side end of the drive cylinder are indicated with X_{S1} and X_{S2}, while the useful length of the cylinder, which is computed from the cylinder length minus piston length, is referenced with X_{Zyl}. Herein this is concerned with the maximal piston stroke. The position X_{S1}, X_{S2} of the cylinder switch sensors and the useful X_{Zyl} are known.

[00019] The object of the invention is the calculation of a position of X_x or, as the case may be, the associated time t_x for the piston passage through at location X_x, from which point the reversible pump must be reversed, so that a complete piston

stroke without hard banging at the cylinder base can be achieved. This position is dependent upon the conveyed amount, however is independent of the position of the cylinder switch sensors (See Fig. 4). The speed V_K of the piston is produced from the useful length X_{Zyl} and the stroke time t_{Hub} as well as the acceleration and brake paths and times X_{Beschl}, X_{Brems}, t_{Beschl}, t_{Brems} as:

$$V_K = \frac{X_{Zyl} - X_{Beschl} - X_{Brems}}{t_{Hub} - t_{Beschl} - t_{Brems}}$$

[00020] The brake (deceleration) or initiation point for reversal follows as:

$$X_x = X_{Zyl} - X_{Brems}$$

[00021] Wherein for simplification a presumption is made of a constant brake acceleration b_{brems}:

$$t_{brems} = V_K/b_{brems}$$

[00022] From this it follows:

$$X_x = X_{Zyl} - ½ \cdot \frac{V_K^2}{b_{brems}}$$

[00023] The brake time point is accordingly calculated as:

$$t_x = t_{Hub} \cdot \frac{X_x}{X_{Zyl}}$$

[00024] A more precise determination of the initiation point is possible, as supplemental information of the piston passage through the switch position S_1 or as the case may be S_2 is undertaken. Thus there is computed for example the time between the stroke start and the switch 1 as:

$$t_{xS1} = \frac{X_{S1}}{X_{Zyl}} \cdot t_{Hub}$$

[00025] For the initiation or start time starting with switch **1** there results the value

$$\Delta t_{x1} = t_x - t_{xS1}$$

[00026] Similar applies for the position x_{S2} of the cylinder switch sensor S_2:

$$\Delta t_{x2} = t_x - t_{xS2}$$

[00027] In the case of the switch S_1 or as the case may be S_2 is passed by prior to the initiation point in time, then the time Δt_{x1} or as the case may be Δt_{x2} will begin after the passage by the cylinder switch sensor. If the cylinder switch sensors lie behind the initiation position, then the initiation time is computed beginning with the beginning of the stroke.

[00028] Analogously to the above described methods of computation the initiation point can also be determined in the case of a change in the conveyed amount. For this the useful length X_{Zyl} is to be divided (stroke shortened) depending upon the change in the conveyed amount, and the new speed V_K of the piston (in the short stroke) be determined for the calculation of the time to brake. This is a known value, based on the required amount to be conveyed.

[00029] The flow diagram of the measurement and evaluation routine **40** in Fig. 5 illustrates the measurement and control processes during the piston movement in the work cylinders. At the positions S_1 and S_2 of the cylinder switch sensors the time point t_{S1} and t_{S2} of the passing by pistons is determined and

therefrom the theoretical stroke time t_{Hub} is computed or calculated. In the case that the conveyor amount is changed in between, this has an impact upon the stroke time t_{Hub} and therewith also upon the piston speed. These values are then taken into consideration in the computation of the initiation time, which finally leads at the point in time t_x or as the case may be Δt_x to initiation of the reverse movement in the pipe switch and the reversible pump.

[00030] In order to ensure a safe and reliable concrete conveyance also in the case of a loss of one or the other cylinder switch sensors S, S_2, there is parallel to the event measurements at the cylinder switch sensors, a hold back time is input for the stroke time, which independently of the measurement process at the cylinder switch sensors can initiate, via a parallel branch, the reversing of the pipe switch and the reversible pump.

[00031] In summary the following can be concluded: The invention relates to a device and a method for controlling a two-cylinder thick matter pump comprising delivery pistons that are actuated in a push-pull manner by means of a hydraulic reversible pump **6** and hydraulic drive cylinders controlled by said pump. For each pressure stroke, the delivery cylinders **50**, **50'** are connected to a delivery conduit **58** by means of a pipe switch **56**. At the end of a pressure stroke, a reversal process of the reversible pump **6** and the pipe switch **56** is triggered. The aim of the invention is to obtain a targeted reversal of the reversal pump and the pipe junction, even when the deliverable quantity is varied, whereby the delivery cylinders are completely emptied without pistons slamming or bottoming out in the drive cylinders. To this end, a computer-assisted reversal

device is provided, said device comprising a measuring and evaluating routine for detecting the temporal displacement course of the piston along the path thereof between the two cylinder ends, by measurement and/or calculation, and for calculating a triggering time derived therefrom for the subsequent reversal of the reversible pump and the pipe switch.